Patent Application of

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for

TITLE: METHOD FOR ENHANCING VISIBILITY

CROSS REFERENCE TO RELATED APPLICATIONS

Not applicable.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

SEQUENCE LISTING OR COMPUTER PROGRAM LISTING

Not Applicable.

BACKGROUND – FIELD OF INVENTION

This invention relates to visibility, specifically improving observation of darker objects when mixed with or surrounded by brighter or blinding objects.

BACKGROUND – DESCRIPTION OF PRIOR ART

The use of direct vision devices like eyeglasses, sunglasses, mirrors, binoculars, telescopes, goggles and any type of direct view optics, is well known in the art and is used in variety of applications.

The prior art vision enhancing methods for direct view optics operates equally on the entire image (limited by the system Field Of View -FOV).

As an example we can look at the use of prior art car rearview or sideview mirror. The prior art mirror systems, active or passive, reflect the image directly or through an attenuation media. Very bright images, like those seen at night on a car's rearview mirror, can cause the driver to be temporarily blinded, and miss a significant part of the image. By tilting the mirror few degrees, part of the light is reflected from the mirror surface rather than from the reflective surface behind the glass, thus creating a dimmed image of the entire view. Another type of car mirror has a controlled shutter/filter that changes the entire FOV transparency by electronically driving an Electro-Chromic coating (or other type of controlled transparent material). This prior art lacks the ability to dim just portions of the image (e.g. the blinding spots) and leave the rest of it unchanged.

As another example we can look at the use of prior art sunglasses or eyeglasses. In case where bright objects are surrounded by dark areas (e.g. at night) or where dimmed areas are surrounded by bright environment (during the day) the viewer suffers from blind areas and reduced visibility, due to eyesight adjusting to the average brightness (Eye Iris). The prior art controls the transparency of the glasses by a shutter/filter via an electronic ambient light sensor, which drives an Electro-Chromic coating or by using Opto-Chromic material embedded in the glass activated by the UV when in sunlight environment. Using these methods to adjust the transparency of the glasses allows the entire image to be controlled. This prior art suffers from lack of ability to dim just the disturbing blinding spots/areas and leave the rest of image areas in the proper contrast level.

Another example is the well known prior art car mirrotdepicted in Fig 1a, where the front glass surface is mounted at an angle to the reflecting surface behind it. When the mirror is "flipped" up, the reflecting surface actually points toward the ceiling, so the image is not directly seen by the observer. Instead, the image reflected off the front of the glass is viewed. This image is dimmer than the one normally reflected, so the driver is not blinded.

Another yet example is the Auto-dimming mirror prior art, which is using a transparency controlled medium in front of the mirror. The transparency is controlled by utilizing the electro-optic or Electro-Chromic characteristics of the

material (Fig 2). The ambient light sensor [22] located near the system, senses the light, and changes the control voltage at the battery/power source [13]. This voltage change drives the active shutter [12] to the proper transparency, such that the image reflected from the mirror [11] looks dimmed to the viewer's eye [33]. The bright spots [14] and dark areas of interest [15] are dimmed at the same magnitude which prevents blinding the viewer on one hand, but provides an obscured image of the area behind him on the other. This prior art lacks the ability to dim just portions of the image (e.g. the blinding spots, very bright areas, etc.) and leave the darker areas in the proper contrast level.

Another prior art (5,760,962 Automatic rearview mirror system using a photosensor array, Schofield , et al. , June 2, 1998) controls the reflectivity of the rear and a side view mirrors using a sensor array. This sensor array covers wide FOV for both mirrors. This prior art suffers from a number of disadvantages:

I) when there is blinding light from behind, the sensor array identifies the portion of the image which has a high intensity, and changes the reflectivity of the pertaining mirror segments. However, since the blinding light falls on the entire mirror, the driver will still be blinded if she moves her head, looking at the mirror from a different angle.

II) The sensor or sensors array it utilizes to measure the light intensity is separate from the mirror or attached to a small portion of it, thus requiring alignment with the mirror for proper operation.

Another prior art Electrically Controllable Optical Filter Element (US Patent 5,510,609, Ackermann, April 23, 1996) contains optoelectric transducer elements, electronic circuit means and a lens that is located in front of the light sensitive sensor only. The only position by which the sensor correlates with the filter elements is when the viewer is looking perpendicular to the plane of the wafer. However, in the case of a car rearview mirror, when a slanted mirror is mounted behind the filter elements, the bright light spots will not be correlated with the reflected image due to driver looking at the mirror from an angle.

Another prior art (5,351,151 Optical filter using microlens arrays, Levy, et al, September 27,1994) controls the light by using arrays of small lenses and nonlinear

optical materials to solve the generalized spatial and spectral optical filtering problem. This solution is segmented by using micro lenses array in such that each particular lens on one side of the array needs to align perfectly to the second array.

This prior art suffers from major disadvantage, like distorted and blurred image due to light leaks between the lenses and lack of reconstructing the segmented images into one image. In addition, the transflector materials used with homogeneous layer cause a substantial latency and delay in the response of the filter to changes in light.

OBJECTS AND ADVANTAGES

Accordingly, besides features of the controlled optics described in prior art, several objects and advantages of the present invention are:

a) To provide enhanced visibility for optical systems by automatically reducing the effect of strong, blinding light spots when viewing dark images.

b) To provide an optical system that operates on the entire image

c) To provide the ability to enhance the visibility by controlling the intensity of the different image elements.

d) The ability to keep the controlled bright element even if the observer is moving his sight position or angle.

e) The ability to add this device (LCP) to optical systems or arrays that generate a secondary images.

f) To provide a method for enhancing visibility not only for automotive use, but also for telescopes, binoculars, goggles, glasses, cameras, etc.

To provide a method that can be used for devices at any frequency range in the electromagnetic spectrum.

SUMMARY OF THE INVENTION

In accordance with this invention a method for enhancing visibility at various light conditions, comprising steps like focusing the desired object or view (source image) on a light modulating device, modulating the light of the focused image (object) by a system like a Light Control Panel (LCP) and projecting the enhanced image with or without magnification.

BRIEF DESCRIPTION OF THE DRAWINGS

Drawing Figures

Figure 1a- Prior Art Car Rearview Mirror -Normal Position

Figure 1b- Prior Art Car Rearview Mirror – Flipped position

Figure 2- Prior Art Active Rearview Mirror

Figure 3- Light Controlled Panel (LCP)

Figure 4- Innovated Visibility Enhancing Device (VED)

Figure 5a- VEM Implementation for Car Mirror – Direct Light Control

Figure 5b- VEM Implementation for Car Mirror – Retro Light Control

Figure 6 – VEM implementation on Glasses

Reference Numerals in Drawings

11 – Mirror

12 – Electronic Shutter

13 – Battery

14 – Bright Spot

15 – Dark Area

16 – Embedded Battery and Electronics

17 – Dimmed Spot

18 – Row Electrode Bus

19 - Capacitor

20 – Column Electrode Bus

21 - Transparent Conductor (Coated Glass)

22 – Light Sensor

23 – Visibility Enhancing Device (VED)

24 – Matrix array of transparent electrodes on surface of semiconductor chip

25 – Matrix of Transparent Electrodes

26 – Light Sensitive Element (LSE)

27 – Transparent Pixel Electrode

28 – Transparency Control Material

30 – Collimating Optical array1

31 – Collimating Optical array2

32 – Light Control Panel (LCP)

33 – Observer

34 – LCP Control

35 – Angled Mirrors

36 – Tilted Mirror

37 – Enhanced Light Control System

41 – Glasses Temple

42 – Glasses Frame

43 – Contrast Control Knob

44 – Rotating Optical Array

45 – Diffractive Collimating Optics 1

46 – Diffractive Collimating Optics 2

DETAILED DESCRIPTION OF THE INVENTION

The Visibility Enhancing Method (VEM) offers automatic image enhancement to common optics in-use today at various visibility conditions. By using devices such as the Light Control Panel (LCP), the VEM provides the ability to control separately some or all picture element, while keeping the other elements almost intact. In the Visibility Enhancing Method (VEM), a Light Control Panel (LCP) **32** is used to generate an active pixilated panel (Fig 3).

The Light Control Panel (LCP) produces the selective image elements and an optical array collimates the image elements and optically directs them to the LCP's focal plane. The image is transferred through the LCP (creating a sub-image) and via the complementary collimating optical array towards the observer eyes or to another optical system. Typically the optical power (magnification) of the system is one. The same collimating optics used for the complementary optics can be used to compensate for geometric distortion.

The LCP consists of pixilated array with a Thin Film (TF) light sensitive device for each pixel. Each pixel's transparency is controlled by the amount of light that shines on it. The panel can be made of transparency-controlled material **28**, comprised of transparent pixel electrodes **27**, controlled by embedded TFT Light

Sensitive Elements (LSE). The transparency of all the elements (Contrast) can be controlled by the magnitude of the voltage that drives the LCP. The TF active element is attached to each Pixel (structure element) to precisely control it. The row and column electrodes used to control the pixels can be formed on the same substrate as the TF array. The driving signals are usually applied to the row (X) electrode of the pixel, and the contrast signal to its column (Y).

A verity of technologies, such as the following, may be used to implement the LCP:

Dichroic Liquid Crystal (LC),

STN- LC (controls a polarized light by two additional polarizing films attached to the outer surface of the device)

Suspended Particle Device (SPD) using the same construction as illustrated in Figure 3 but uses SPD for transparency controlled material [28].

Electrochromic material or coating

The LCP **32** can be used in various pixel shapes, resolution and size to provide the desired optical system and required image quality. The magnitude of LCP's driving voltage can control the visibility level or even completely switch off the enhancement option and return to the regular behavior of an un-enhanced optical device. Typically, when no power is applied to the LCP, the transparency of the panel is set to "Normally Open" state, in order to set the system to a neutral position (maximum transparency) as a fallback.

For some applications a reflective LCP may be used. In these applications the reflected light is controlled by the pixels. For such panels a DLP™ Micro Mirror array manufactured by Raytheon Inc. may be used.

An example of a device based on the Visibility Enhancing Method (VEM) is illustrated in **Fig 4-**. The incident light **14, 15** is collimated by the Optical Array1 **30** and produces an imaginary image on the LCP **32**. This image passes through the device that attenuates the desired elements. The image is then collimates back by the Complimentary Collimated Optical Array2 **31**. The enhanced image, which is rotated 180 degrees, can be rotated back if desired by any related optics. For

example, the device can be used as an add-on to a camera, and the created image can be rotated back during the printing process.

The visibility enhancing method can be implemented on various types of optical devices, like car rear or side mirror, enhanced optical goggles, camera lens, spectacles, eyeglasses, sunglasses, glare-shield, window, or any enhancing optical device or protection devices like LASER or arc welding goggles.

As an example example, a car mirror based on the Visibility Enhancing Method is described in **Fig 5a**. The Light Control Panel **32** creates an image on a prism or slanted mirrors **35** towards the observer eyes **33**. As stated before, the bright image elements pass through the Enhanced active optical Device and are dimmed by the LCP while the other elements pass undisturbed (or with minor attenuation) to the viewer. The image contrast is controlled automatically, or manually by the LCP drive **34**.

Another example for a car mirror is a retro-optical array that may be implemented as illustrated in **Fig 5b**. In this example the light passes through an optical system comprising a Collimating Optical Array1 **30** and a reflective LCP **32** that control the light intensity, and reflects it to the observer. The reflective LCP may be constructed of reflective pixel element within the LCP, or a transparent LCP attached to reflective surface.

As an another example of the Visibility Enhancing Method, the Visibility Enhancing Glasses, depicted in **Fig 6** can be used. Linear optics, binary optics, holographic optics,diffractive optics, or any surface implemented optics may comprise the optical array that can be installed on standard glasses. The glasses visibility enhancing optical array is comprised of collimating diffractive Optical Film Array 1 **45** and produces an imaginary image on the LCP **32**. The image passes through the LCP which attenuates the desired elements, and is collimated back by the complimentary collimating diffractive Optical Film Array 2 **46**. The image is then rotated by a film diffractive array **44** towards the observer 33.

For resolving implementation difficulties associated with the Optical Film Array, products like Lenticular Lens or Microlens Technology can be used.

For resolving implementation difficulties associated with the LCP, a variety of reflected image sources and technologies is available through Flat Panel Display (FPD) vendors. As one of the options, the same process that is being used for producing micro-displays and flat panel displays can be used to make the LCP with the exceptions that the black mask is not required and the TFT (Thin Film Transistor), which controls the optical array, is deposited such that it is light sensitive.

Devices like LCD (R-LCD), STN-LCD produced by companies such as SONY Co, Tokyo, JAPAN. SHARP Co, Osaka JAPAN, and Liquid Crystal on Silicon (LCoS) devices produced by companies such as Displaytech, Longmont, CO, USA, MicroPix of Dalgety Bay, Scotland UK and Three-Five Systems, Tempe, AZ USA, can be used.

CONCLUSION

Accordingly, the reader will see that the Visibility Enhancing Method of this invention has a unique ability to control the brightness of image elements and improve visibility, especially in light conditions where dimming the entire image should be avoided. The Visibility Enhancing Method can be implemented on almost any optical device. In addition, the same approach which is used for the human vision spectrum may be used for other light spectra (Near IR, IR, and LASER) where the optical elements and LCP are optimized to that spectrum.

The invented Visibility Enhancing Method can be used in optical systems like conventional vision optics with a direct view, optical arrays like those used in cameras, and more.

Although the description above contains many specifities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention. For example, different types of optics can be used for collimating the light, the Light Control Panel May have different shapes, the reflecting mirror can be mounted at various angles to the LCP, etc. Thus the scope of the invention should be also determined by the appended claims and their legal equivalents, rather than only by the examples given.